PEST MANAGEMENT GRANTS FINAL REPORT

NEMATODE AND WEED SUPPRESSIVE COVER CROPS AS REPLACEMENTS FOR METHYL BROMIDE

Agreement No. 01-201C

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July 29, 2003

Prepared for the California Department of Pesticide Regulation

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ACKNOWLEDGEMENTS:

Shengping Yang, Edmond Ogbuchiekwe, John Darsow, Guangyao Wang, and Xuebiao Gao conducted the experiments and helped analyze the data. This report was submitted in fulfillment of Agreement No. 01-201C, Nematode And Weed Suppressive Cover Crops As Replacements For Methyl Bromide.

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ABSTRACT

Nematode and Weed Suppressive Cover Crops for Sustainable Pest Management

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Mixtures of cowpea and sudangrass cover crops affected weeds, root-knot nematodes, and yields of subsequently grown carrots in coastal and desert experiments. In the low desert climate of the Coachella Valley, a sudangrass-cowpea mixture caused the greatest reduction in weed populations. Compared to fallow control treatments, cover crops did not affect root-knot nematode densities. In the cool South Coast coastal climate, the warm season cover crops grew poorly and did not reduce weed populations. Cover crop treatments with a high (>25%) percentage of sudangrass resulted in higher root-knot nematode populations compared to cover crop treatments containing mostly (≥75%) cowpea or fallow controls. The yield and quality of carrots grown after the cover crop treatments was not different from the fallow control at any of the two sites. An economic analysis showed that cover cropping gave the highest net return in the desert. At the coastal field site, there was not a clear economic benefit from cover crop.

REPORT

OBJECTIVE 1: Optimize the species ratio of sudangrass and cowpea mixtures for root-knot nematode and weed suppression.

HYPOTHESIS: The ratio of sudangrass to cowpea density in cover crop mixtures changes nematode and weed populations.

OBJECTIVE 2: Prepare cost of production studies.

HYPOTHESIS: Cover crops can increase economic return compared to fallow and fumigation treatments.

MATERIALS AND METHODS

Cover crops were planted at both the Coachella Valley Agricultural Research Station in Thermal, and the South Coast Research and Extension Center in Irvine, CA. in 2002. Cover crop treatments included: 100% cowpea, 75% cowpea and 25% sudangrass, 50% cowpea and 50% sudangrass, 25% cowpea and 75% sudangrass, 100% sudangrass, untreated control, and chemical control. For chemical control, 75 gal/acre metam sodium was applied before planting of carrots.

Treatments were arranged in a randomized complete block design with four replications on 51cm beds. Each experimental unit was an 8.3m length of bed. Drip tapes were placed on the surface of each bed to irrigate cover crops and the subsequent carrot crops. 'Iron Clay' cowpea 'Trudan - 8' sudangrass were planted in Thermal on July 12th. Cover crop residues were chopped and incorporated on Sept. 8th. In Irvine, cover crops were planted on July 25th and chopped and incorporated on Sept 27th.

Fertilizer and Insecticides

No fertilizer or insecticide was applied during the cover crop season.

Plant Canopy Width Measurement

Plant canopy width was measured in cm at two randomly chosen locations in each plot and averaged. The sampling dates were: July 29th, Aug. 5th, Aug. 14th, Aug. 22nd, and Aug. 29th in Thermal; and Aug. 12th, Aug. 20th, Aug. 28th, Sept. 10th, and Sept. 18th in Irvine.

Percentage Light Density Measurement

Percentage light densities were measured on July 29th, August 5th, August 14th, August 22nd, and August 29th in Thermal, and Aug. 12th, Aug. 20th, Aug. 28th, Sept. 10th, and Sept. 18th in Irvine.

Light density was measured with a Line Quantum Sensor from LI-COR, Inc. The cover crops were planted in the North- South direction, and the Line Quantum Sensor was placed parallel to the plant rows. Data were taken from four locations under the canopy. The four locations were named from west to east as distance 1 position 1, distance 0 position 1, distance 0 position 2 and distance 1 position 2, respectively. All the measurements were conducted on clear days from 11:00 to 12:00.

Distance 0 - There was no distance between the Line Quantum Sensor and the plants.

Distance 1 - The Line Quantum Sensor was put on the edge of the bed.

Position 1 - The west side of the bed.

Position 2 - The east side of the bed.

In order to minimize the error caused by the movement of the sun, no measurements in other replications were taken until all the measurements in one replication were completed.

Weed Evaluation and Control

Weeds were sampled beginning three weeks after cover crops were planted.

The number of each weed species within a randomly selected 75 cm × 60 cm area was counted on: July 29th, August 5th, August 14th, August 22nd, August 29th, and Sept. 5th in Thermal, and Aug. 12th, Aug. 20th, Aug. 28th, Sept. 10th, and Sept. 18th in Irvine.

Weed samples were harvested on August 22nd and 29th from Thermal. All the weeds within an area of 1 m × 50.8 cm were harvested on Aug. 22nd, and weeds within an area of 60 cm × 50 cm were harvested on Aug. 29th. All the harvested weeds were dried at 70℃ until a constant weight was reached.

Nematode Population Evaluation

Nematode populations were sampled and analyzed before the cover crop season on July 12th, and after cover crop incorporation on Sept. 13th. Five sub-samples were taken in each plot. Sub-samples for each plot were mixed and nematodes were extracted on modified Baerman funnels at 26 ℃ for 5 days.

Carrot Production

Carrot crops were grown after cover crop incorporation as per the typical cultural practices of commercial carrot growers in Southern California.

Carrot leaf petiole nutrient condition analysis

Carrot leaf petioles were sampled on Jan 10th in Coachella Valley, and on Jan. 17th, 2003 at South Coast, and carrot leaf petiole nutrient contents were analyzed.

Nematode Infested Carrot Analysis

Nematode free and infested carrots were separated after harvesting and fresh weight and number of marketable and non-marketable carrots was recorded.

Net Profit Analysis

Sources of costs of each pest control options were compared and analyzed, and net profits were calculated.

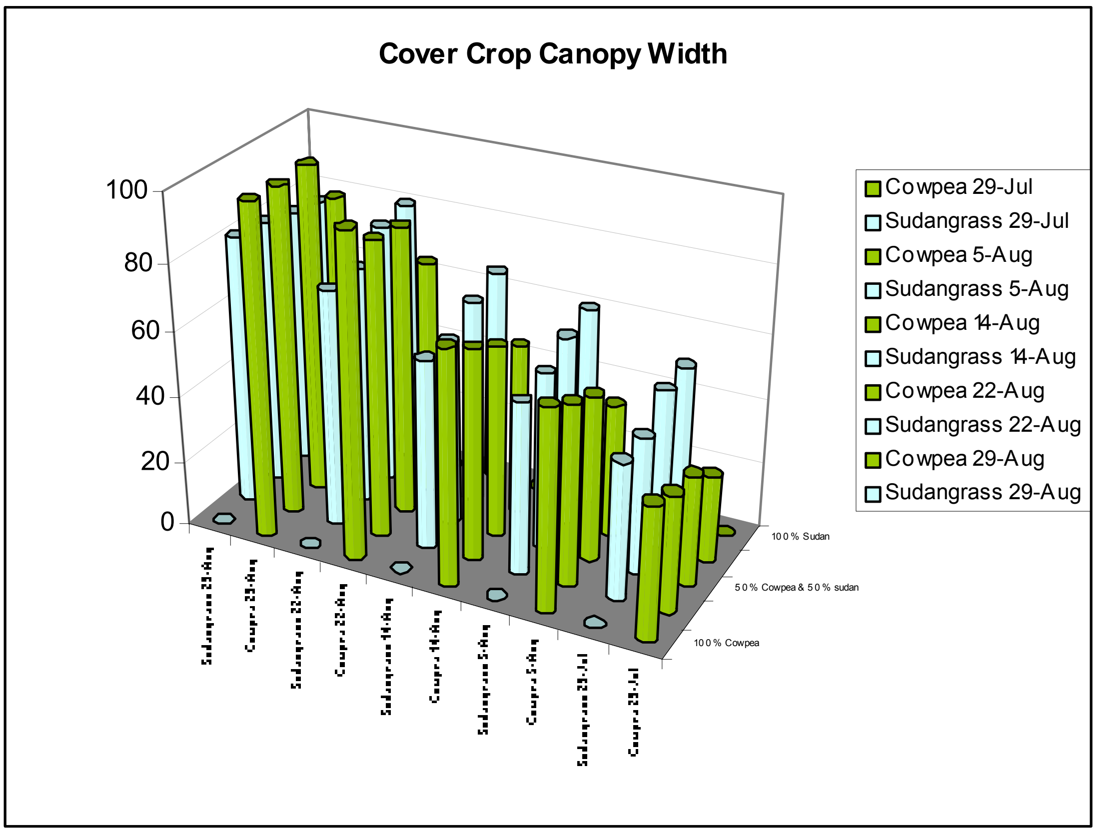
RESULTS AND DISCUSSIONS

<u>Coachella Valley Experiment</u>

Plant canopy width measurement

Canopy width: Canopy width is a measure of how far plants grow out into the furrow, or away from the center of the row where competition with other cowpea or sudangrass is more intensive. It also indicates how fast the cover crop can cover the soil surface. For both cowpea and sudangrass (Fig. 1), canopy width was greatest when grown in monoculture. The canopy width of cowpea consistently declined as the percentage of cowpea in the mixture declined. This suggests that cowpea competed more strongly with itself than with sudangrass. However, late in the season cowpea fell over (lodged) and began to grow closer to the ground as a vine. The lower vining growth of cowpea opened areas higher up in the canopy that could be occupied by sudangrass.

Fig.1. Cover crop canopy width at different growing stages



For the first half of the season, sudangrass canopy width was also greatest when grown in monoculture without cowpea. Sudangrass appears to compete more strongly with itself than cowpea, and avoids some of the competition by growing slightly outward away from the center of the row. However, by the end of the season, sudangrass canopy width was statistically equivalent whether grown in monoculture or with cowpea.

Percentage light density measurement

Light intensity**:** Light intensity was measured above the soil surface and below the plant canopy, with ambient light density as the background. Data are presented as a percentage of the ambient or unshaded light intensity. The data (Fig. 2,3,4,5) represent the amount of light that passes through the canopy to the soil without being intercepted by either sudangrass or cowpea. The denser the cover crop canopy, the lower the light intensity.

The light intensity data parallel the conclusions drawn from the weed count and cover crop canopy width data. The 100% cowpea (monoculture) treatment had the least amount of light passing through to the soil in the early season. But as cowpea began to lodge and grow along the ground as a vine, the leaves of the cowpea monoculture intercepted less and less light and were less effective in shading the soil (Fig. 2, 3, 4, 5).

The change in light intensity under the sudangrass canopy followed the opposite seasonal pattern of the cowpea canopy. Sudangrass seedlings grew leaves more slowly than cowpea. But once sudangrass was established, it rapidly formed a dense, shading canopy. Sudangrass dominated the upper canopy that was vacated when cowpea began to vine. By the end of the season, increasing the proportion of sudangrass in the cover crop mixture resulted in less light reaching the weeds growing under the canopy (Fig. 2, 3, 4, 5).

The experiment was irrigated and fertilized to prevent water or nutrients from becoming limiting factors for plant growth. However, there was often strong competition for light among individual sudangrass or cowpea plants. The more light the cover crop intercepted, the less light left available for weed germination and growth.

Fig.2. Percentage light density under the cover crop canopy.

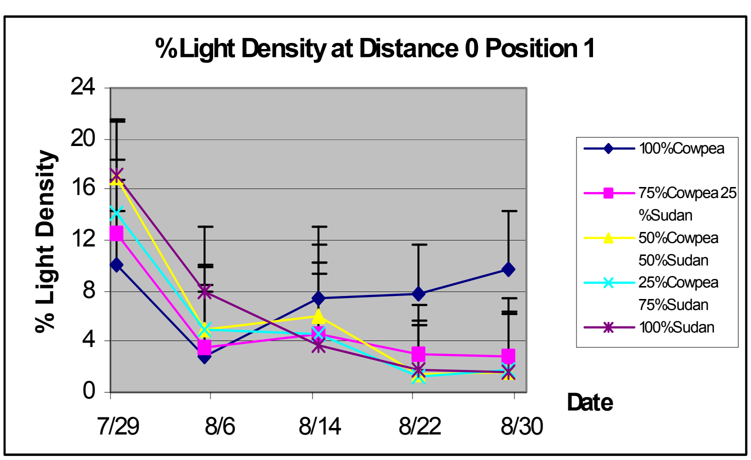


Fig.3. Percentage light density under the cover crop canopy.

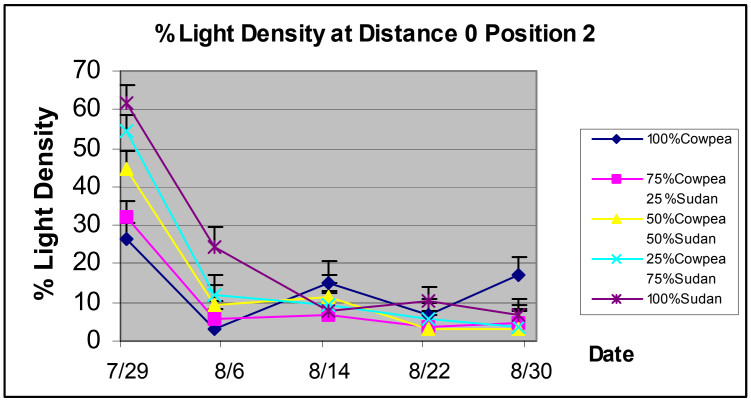


Fig.4. Percentage light density under the cover crop canopy.

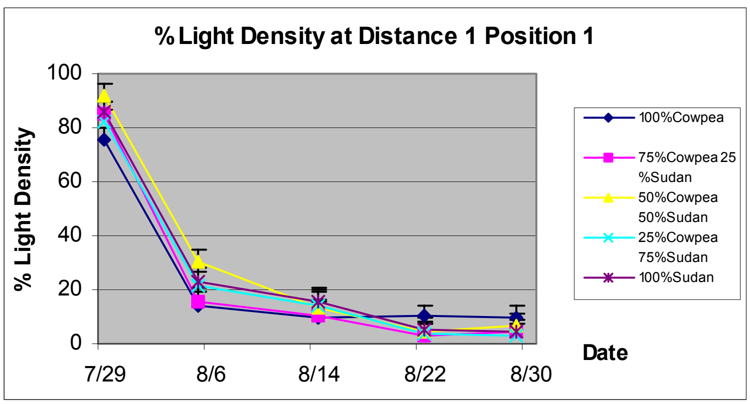
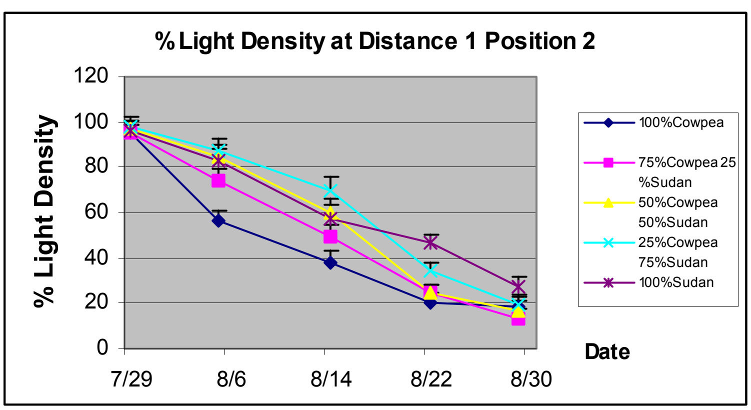


Fig.5. Percentage light density under the cover crop canopy.



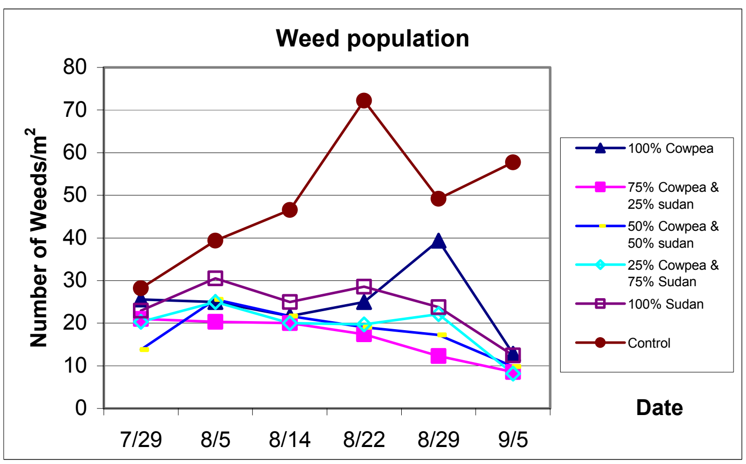
Weed population measurement

Weed population counts: The unweeded control, with no cover crops to compete with weeds, had the highest weed populations (Fig. 6). These data represent the weed populations a grower would face if he had not planted cover crops. The predominant weed at the Coachella Valley site was nutsedge, with some lovegrass, pigweed, and foxtail.

Weed populations appeared to respond to growth differences in the two cover crop species. Cowpea has a C_3 metabolism and a large seed, which allows cowpea seedlings to grow rapidly. Sudangrass has a C_4 metabolism and smaller seeds, so while seedling growth is slower, its high photosynthetic rate means that subsequent growth is rapid in the high light and high temperature of summer.

Cowpea grown in monoculture (100% cowpea, i.e. not mixed with sudangrass) had the fewest weeds early in the season, but the population grew as the season progressed. Conversely, the 100% sudangrass treatment maintained similarly low weed populations on all sampling dates. Mixtures of both sudangrass and cowpea generally had fewer weed populations than monocultures of either species on most sampling dates.

Fig.6. Weed population at different stages



Cover crop dry biomass

The dry weight of the leaves and stems of cowpea in the cover crop mixtures was roughly proportional to the ratio of cowpea:sudangrass seeds planted at the start of the experiment (Fig. 7, 8). For the cowpea monoculture, 795 gram/m^2 were harvested, and proportionately less were present in the 50:50 mixture (378 gram/m^2, or roughly half the weight in the 100% cowpea treatment) and the 25% cowpea: 75% sudangrass mixture (239 gram/m^2). The number of cowpea and sudangrass plants present at harvest was used to calculate the final ratios of each species for a regression analysis.

In the regression analysis, the dry weight of cowpea in different mixture treatments has a linear relationship (Fig. 7, 8) with the cowpea:sudangrass ratio. The linear relationship between cowpea dry weight and cowpea density means that the average weight of each cowpea plant remained constant at all cowpea or sudangrass densities. Cowpea growth was similar whether competing with sudangrass or other cowpea plants. The high R^2 values (0.79 to 0.84) confirm that cowpea density had a direct, linear relationship with cowpea weight (Fig. 7, 8). Sudangrass dry weight also had a linear relationship with the sudangrass:cowpea ratio. At the total density used in these experiments, neither cowpea nor sudangrass was affected by changes in the ratio of either species.

Sudangrass produces more biomass than cowpea in a growing season, and sudangrass had a faster biomass increase than cowpea at the late growing stages (Figure 7 and 8). Dry weight increased from 1617g/m^2 to 2281g/m^2 from August 22nd to August 29th in the 100% sudangrass treatment. However, for the 100% cowpea treatment, dry weight didn't change during the same period. Since both of the treatments are monocultures, we concluded that vegetative growth of sudangrass was much faster than cowpea at the late growing stages. By the end of the cover crop season, the sudangrass monoculture had the highest dry weight among all the treatments. The rapid biomass production of sudangrass late in the season indicates that time of harvesting is a critical determinant of total dry biomass. Since cowpea and sudangrass may have different plant tissue N content, harvesting time thus may also affect the C/N ratio of the plant residues that incorporated into the soil. The C/N ratio has direct consequences for soil quality and nutrient availability for subsequent cash crops.

Fig.7. Cowpea and sudangrass dry weight (Aug. 22nd)

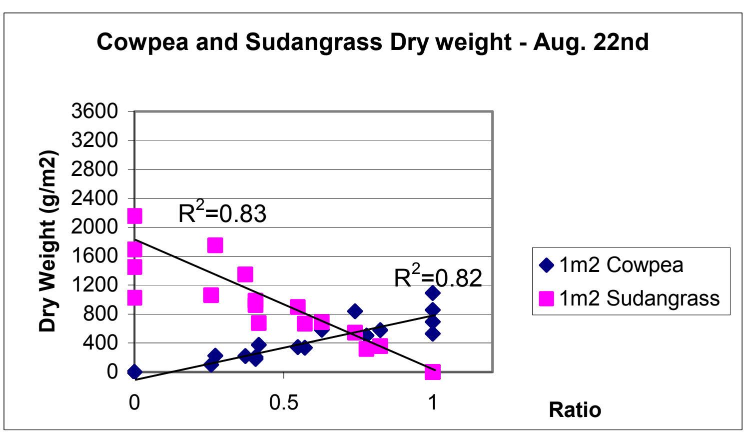
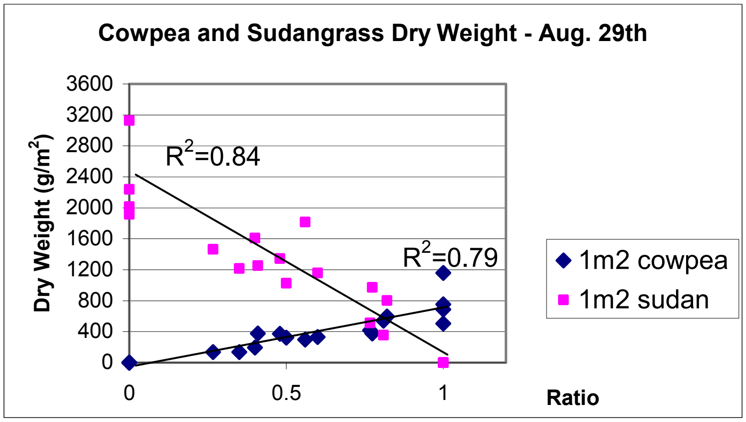


Fig.8. Cowpea and sudangrass dry weight (Aug. 29th)

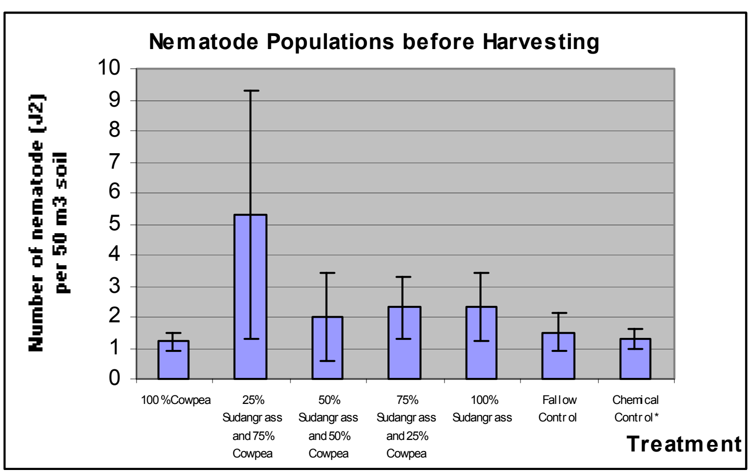


Nematode population analysis:

Nematode population analysis: There were no significant differences between the second-stage juvenile (J2) populations of *Meloidogyne incognita* in different treatments before cover crops were planted (Fig. 9).

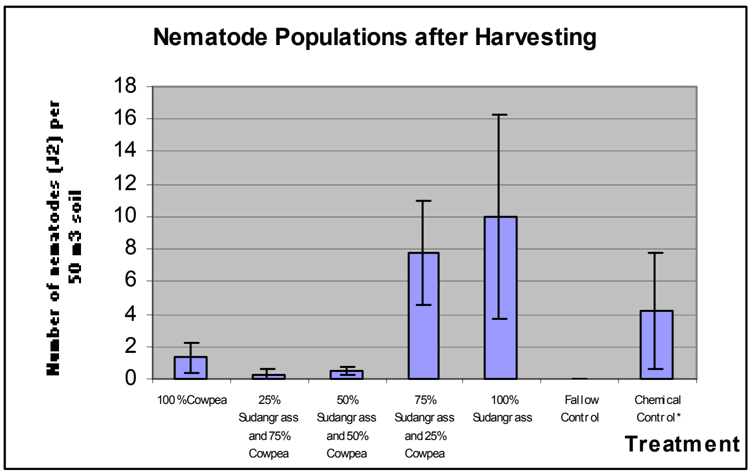
The J2 populations in the 100% sudangrass, and 75% sudangrass + 25% cowpea treatments were significantly higher than in the fallow control at the end of the cover crop season (Figure 10). No significant differences were found between the fallow control and the following treatments: 50% sudangrass + 50% cowpea, 25 sudangrass + 75% cowpea, and 100% cowpea.

Fig. 9. The second-stage juvenile population densities of *Meloidogyne incognita* before seeding of cowpea and sudangrass in two localities (J2 per 50 cm^3 soil), chemical control had not been applied at the time of sampling.



There are two possible reasons for this phenomenon. First, the higher ratio of sudangrass treatments had denser canopies, which probably lowered the temperature of the soil surface. In the desert summer, nematodes can be more active when the soil surface temperature is lowered. Second, soil moisture levels in sudangrass treatments are higher than those in the fallow control, which could improve the viability and survival of nematodes in the top layer of soil. In less favorable conditions, the J2 nematodes are likely to move deeper into the soil where there is less stress from temperature or moisture content.

Fig. 10. The second-stage juvenile population densities of *Meloidogyne incognita* after harvesting cowpea and sudangrass in two localities (J2 per 50 cm^3 soil), Chemical control had not been applied at the time of sampling.



Nematode infestation on carrots:

Fresh weight and number of nematode infested carrots were equivalent for all treatments. There were no treatment differences for number or fresh weight of marketable carrots.

Carrot leaf petiole nutrient analysis:

The entire experiment was uniformly fertilized during carrot growth to prevent nutrient differences from confounding experimental results. Carrot leaf petiole nutrient content was equivalent for all the treatments indicating that field nutritional conditions did not affect treatment differences.

Net benefit analysis

The net returns of cover crop treatments were all higher than that of the fallow control treatment and much higher than that of the chemical control treatment (Table 1). Therefore, all sudangrass:cowpea combinations were economically sound solutions for carrot production.

The net cost of the fallow control treatment and the chemical control treatment were high in our analysis. This is mainly due to the high cost of applying Metam Sodium in the chemical control treatment, and the higher cost of hand weeding in the fallow control treatment.

Table 1. Projected returns, costs and value of cover crop incorporated in growing desert carrot($/Ha.)

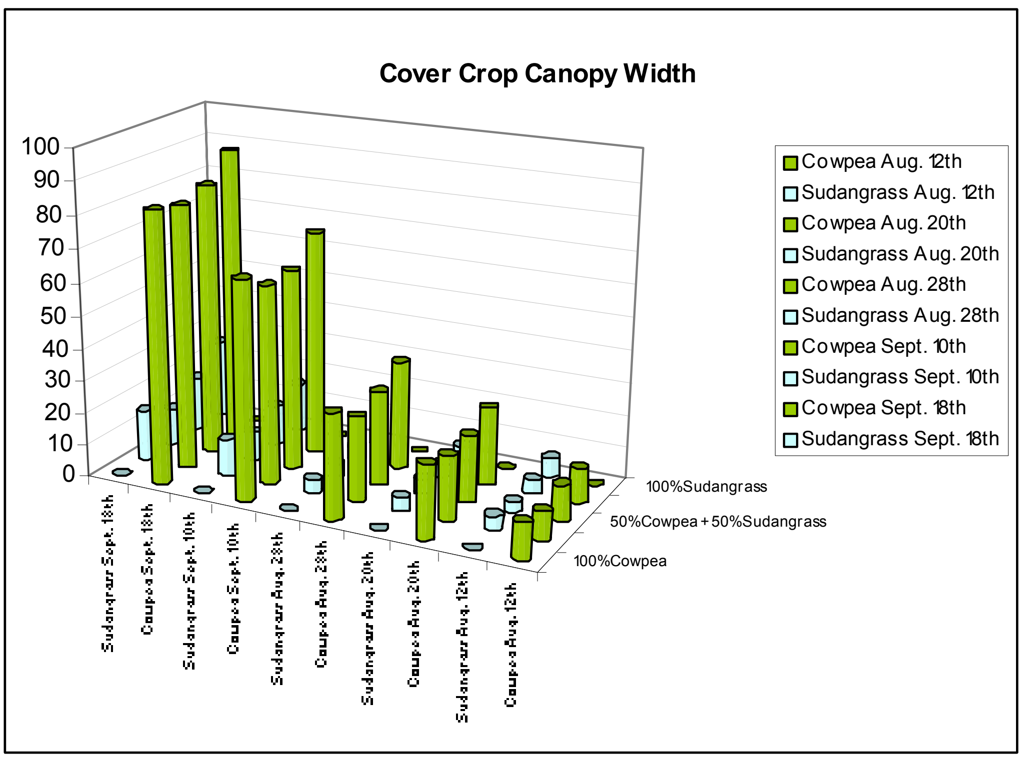
Operations (Land Preparation)	100%-Cowpea	25% Sudangrass/ 75% cowpea	50% Sudangrass/ 50% Cowpea	100% Sudangrass	75% Sudan/ 25% Cowpea	Untreated Control	Chemical Control
	Returns & costs/HA						
BENEFIT							
Average yield ton/Ha	***13.35***	***12.13***	***13.43***	***13.13***	***12.30***	***13.01***	***12.73***
Gross return (base on $420/Ha)	5607	5094.6	5640.6	5514.6	5166	5464.2	5346.6
LAND PREPARATION COSTS							
Stubble Disc1x	53.72	53.72	53.72	53.72	53.72	53.72	53.72
Subsoil	95.71	95.71	95.71	95.71	95.71	95.71	95.71
Disc 1x	56.81	56.81	56.81	56.81	56.81	56.81	56.81
Land plane 2x	59.28	59.28	59.28	59.28	59.28	59.28	59.28
Border, cross check & break borders	43.84	43.84	43.84	43.84	43.84	43.84	43.84
Disc 1x	28.41	28.41	28.41	28.41	28.41	28.41	28.41
Metam sodium	***0.00***	***0.00***	***0.00***	***0.00***	***0.00***	***0.00***	***435.34***
Disc 1x	28.41	28.41	28.41	28.41	28.41	28.41	28.41
Triplane 1x	27.17	27.17	27.17	27.17	27.17	27.17	27.17
List 40" beds	33.35	33.35	33.35	33.35	33.35	33.35	33.35
Compost of cover crop-green (@ $5.90/ton)	***4.01***	***8.09***	***7.91***	***8.32***	***7.97***	***0.00***	***0.00***
TOTAL LAND PREPARATION COSTS	**430.70**	**434.78**	**434.60**	**435.01**	**434.66**	**426.69**	**862.03**
GROWING PERIOD COSTS							
Seed	424.84	424.84	424.84	424.84	424.84	424.84	424.84
Spike 2x	48.17	48.17	48.17	48.17	48.17	48.17	48.17
Irrigation 6x	307.14	307.14	307.14	307.14	307.14	307.14	307.14
Hand weeding 2x @ $7.75/hr	***592.80***	***639.73***	***560.69***	***528.58***	***396.43***	***973.18***	***694.07***
TOTAL GROWING COSTS ($)	**1372.95**	**1419.88**	**1340.84**	**1308.73**	**1176.58**	**1753.33**	**1474.22**
TOTAL GROWING & PREPARATION COSTS	**1803.65**	**1854.66**	**1775.44**	**1743.74**	**1611.24**	**2180.02**	**2336.25**
Land Rent (net acres)	555.75	555.75	555.75	555.75	555.75	555.75	555.75
Cash Overhead: 10% of growing, prep & land costs	279.36	291.63	317.84	279.06	340.07	311.86	327.48
TOTAL PREHARVEST COSTS	**2638.76**	**2702.04**	**2649.03**	**2578.55**	**2507.06**	**3047.63**	**3219.48**
HARVEST COSTS (base on $160/ha)	2136.00	1940.80	2148.80	2100.80	1968.00	2081.60	2036.80
TOTAL OF ALL COSTS	***5054.12***	***4934.47***	***5115.67***	***4958.41***	***4815.13***	***5441.10***	***5583.77***
NET RETURN ($/ha)	**552.88**	**160.13**	**524.93**	**556.19**	**350.87**	**23.10**	**-237.17**

South Coast Experiment

Canopy width measurement:

Sudangrass grew poorly at South Coast, and thus the growth of cowpea was not affected by sudangrass. The canopy width of cowpea had some differences among the different treatments at early stages, which may be the result of different cowpea densities in different treatments. Contrary to the Coachella Valley experiment, sudangrass remained small even late in the season, and the growth of cowpea was not impacted by the growth of sudangrass (Fig.11). Sudangrass canopy width was equivalent for all treatments (Fig. 11). Sowing time, local temperature, and the short day-length of this late planting influenced the growth of sudangrass. Sudangrass responds more dramatically to decreases in photoperiod than cowpea. As you move farther away from the longest day of the year ~ June 20th, the more severe is the decline in sudangrass. Cowpea is unaffected by photoperiod and grew better than sudangrass in the South Coast experiment.

Fig. 11. Cover crop canopy width at different stages



Light Density measurement:

The data (Fig. 12-15) show that the light density under the plant canopy was strongly affected by the percentage of cowpea in the treatment -- the general trend is that the higher the percentage of cowpea in the mixture, the more the plant canopy blocked the light. Due to the poor growth of sudangrass at South Coast, the 100% sudangrass treatment could block the least light.

12. Light density measurement

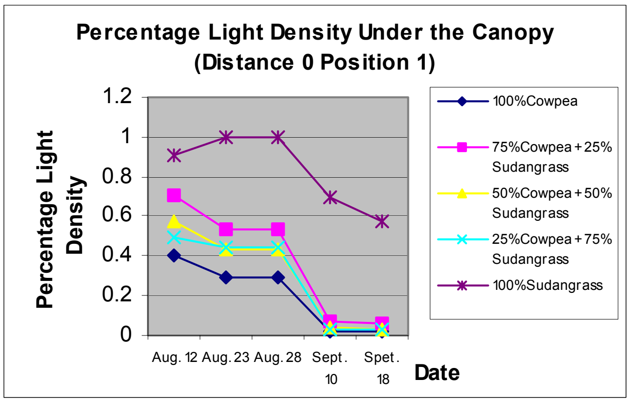


Fig. 13. Light density measurement

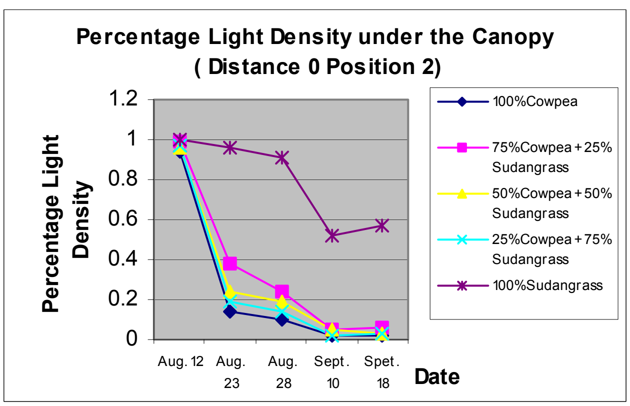


Fig. 14. Light density measurement

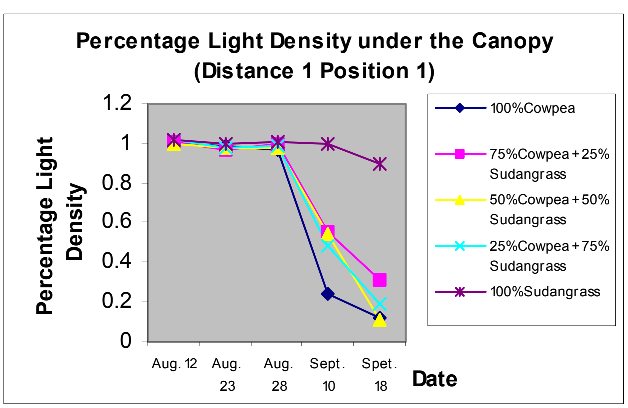
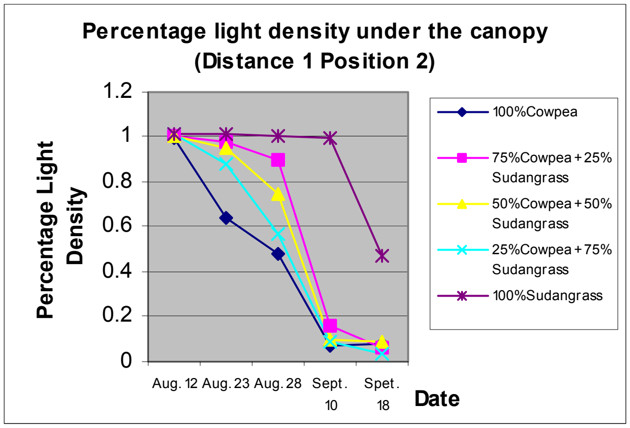


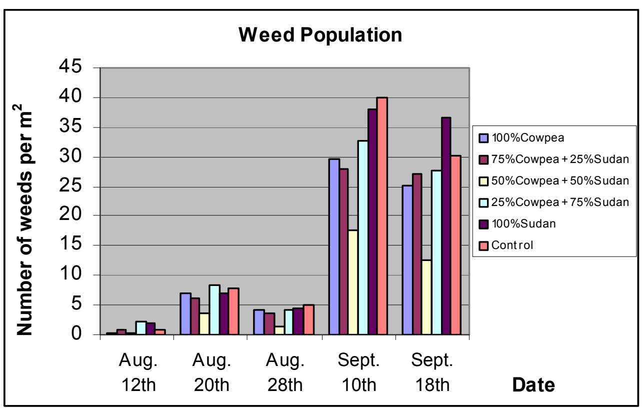
Fig. 15. Light density measurement



Weed population:

Cover crop treatments didn't affect weed populations (Fig. 16). Weed populations were relatively low, but the slow cover crop growth did not significantly suppress the growth of weeds.

Fig. 16. Weed population



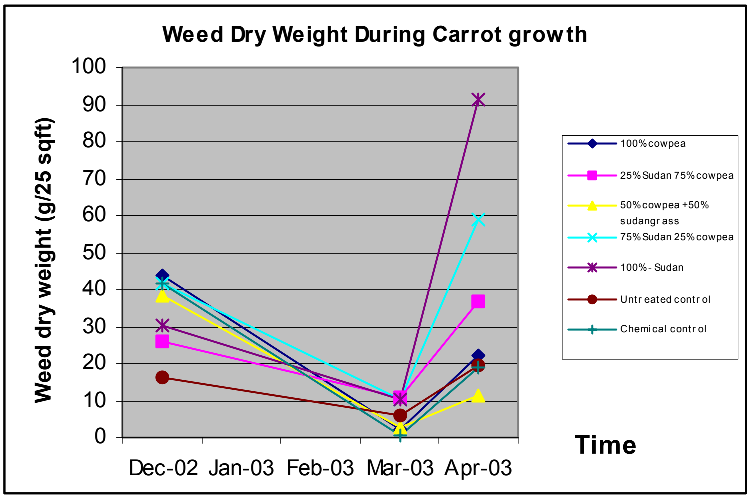
Soil evaluation

Soil evaluation: The soil nutrient analysis found no difference for any soil nutrient taken after incorporation of cover crops, with the exception of Mn^{2+}. All plots were fertilized after planting carrots to ensure adequate fertility for the carrot crop.

Weed dry weight:

There was no difference for any treatment for any of the three weed dry biomass samples (Fig. 17). Cover crop treatments didn't have better weed control than the fallow control. As a result of the poor growth of cover crops, all treatments were equivalent to the fallow control. This may partially result from the low weed populations in both the cover crop and carrot seasons.

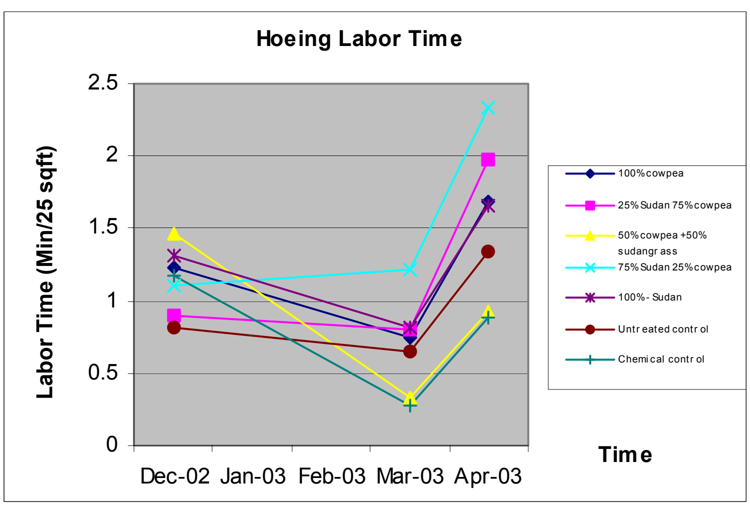
Fig. 17. Weed dry weight



Weed hoeing labor cost analysis:

There was no difference among the treatments in terms of the labor costs for hand weeding.

Fig. 18. Weed hoeing labor time



Nematode Analysis

Nematode Analysis: There were no significant differences between second-stage juvenile (J2) populations of *Meloidogyne incognita* before cover crops were planted.

After the cover crop season, the J2 populations in the 100% sudangrass, 50% sudangrass + 50% cowpea and 75% sudangrass + 25% cowpea treatments were significantly higher than that in the fallow control. No significant differences were found between the fallow control and 25% sudangrass + 75% cowpea, or the 100% cowpea treatments. While Trudan-8 sudangrass is known to be resistant to *M. incognita*, it did not suppress populations at the South Coast location.

Fig. 19. The second-stage juvenile population densities of *Meloidogyne incognita* before seeding of cowpea and sudangrass in two localities (J2 per 50 cm^3 soil), chemical control had not been applied at the time of sampling.

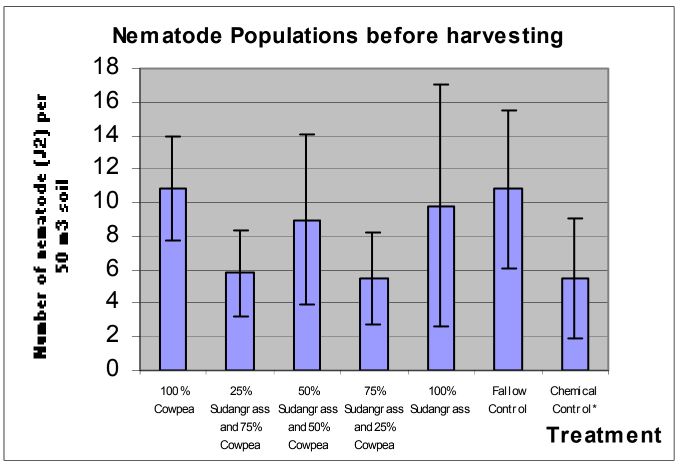
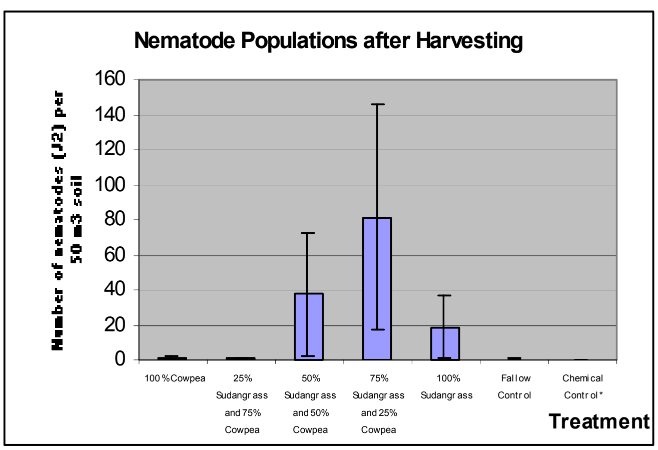


Fig. 20. The second-stage juvenile population densities of *Meloidogyne incognita* after harvesting cowpea and sudangrass in two localities (J2 per 50 cm^3 soil), chemical control had not been applied at the time of sampling.



Nematode infested carrot analysis

All treatments were statistically equivalent.

Carrot leaf petiole nutrient analysis

There was no difference in carrot leaf petiole nutrient content.

Net profit analysis

The chemical control treatment had the highest cost in all the treatment due to the high cost of applying metam sodium. Some cover crop treatments had higher costs than the fallow controls partially because of the poor growth of cover crops; and because weed populations were low at the South Coast site (Table 2).

Table 2. Projected returns, costs and value of cover crop incorporated in growing carrot ($/Ha.)

Returns &costs/HA							
Operations **(Land Preparation)**	100%-Cowpea	25% Sudangrass 75% cowpea	50% Sudangrass 50% Cowpea	100% Sudangrass	75% Sudan/ 25% Cowpea	Untreated Control	Chemical Control
BENEFIT							
Average yield ton/Ha	8.10	7.80	9.15	5.50	7.25	6.98	4.98
Gross return (base on $420/Ha)	3402	3276	3843	2310	3045	2931.6	2091.6
LAND PREPARATION COSTS							
Stubble Disc1x	53.72	53.72	53.72	53.72	53.72	53.72	53.72
Subsoil	95.71	95.71	95.71	95.71	95.71	95.71	95.71
Disc 1x	56.81	56.81	56.81	56.81	56.81	56.81	56.81
Land plane 2x	59.28	59.28	59.28	59.28	59.28	59.28	59.28
Border, cross check & break borders	43.84	43.84	43.84	43.84	43.84	43.84	43.84
Disc 1x	28.41	28.41	28.41	28.41	28.41	28.41	28.41
Metam sodium	***0.00***	***0.00***	***0.00***	***0.00***	***0.00***	***0.00***	***435.34***
Disc 1x	28.41	28.41	28.41	28.41	28.41	28.41	28.41
Triplane 1x	27.17	27.17	27.17	27.17	27.17	27.17	27.17
List 40" beds	33.35	33.35	33.35	33.35	33.35	33.35	33.35
Compost -cover crop-green(@ $5.90/ton)	***4.01***	***8.09***	***7.91***	***8.32***	***7.97***	***0.00***	***0.00***
TOTAL LAND PREPARATION COSTS	**430.70**	**434.78**	**434.60**	**435.01**	**434.66**	**426.69**	**862.03**
GROWING PERIOD COSTS							
Seed	424.84	424.84	424.84	424.84	424.84	424.84	424.84
Spike 2x	48.17	48.17	48.17	48.17	48.17	48.17	48.17
Irrigation 6x	307.14	307.14	307.14	307.14	307.14	307.14	307.14
Hand weeding 2x @ $7.75/hr	***155.00***	***155.00***	***132.00***	***209.25***	***155.00***	***132.00***	***101.00***
TOTAL GROWING COSTS ($)	**935.15**	**935.15**	**912.15**	**989.40**	**935.15**	**912.15**	**881.15**
TOTAL GROWING & PREPARATION COSTS	**1365.85**	**1369.93**	**1346.75**	**1424.41**	**1369.81**	**1338.84**	**1743.18**
Land Rent (net acres)	555.75	555.75	555.75	555.75	555.75	555.75	555.75
Cash Overhead: 10% of growing, prep &land costs	279.36	291.63	317.84	279.06	340.07	311.86	327.48
TOTAL PREHARVEST COSTS	**2200.96**	**2217.31**	**2220.34**	**2259.22**	**2265.63**	**2206.45**	**2626.41**
HARVEST COSTS (base on $160/ha)	1296.00	1248.00	1464.00	880.00	1160.00	1116.80	796.80
TOTAL OF ALL COSTS	**3776.32**	**3756.94**	**4002.18**	**3418.28**	**3765.70**	**3635.12**	**3750.70**
NET RETURN ($/ha)	**-374.32**	**-480.94**	**-159.18**	**-1108.28**	**-720.70**	**-703.52**	**-1659.10**

CONCLUSIONS

In the Coachella Valley, both cowpea and sudangrass grew rapidly and suppressed weeds effectively during the cover crop season. The weed populations in either of the monoculture treatments were significantly lower than the fallow control. Furthermore, cover crop mixtures had better weed suppression than monocultures, and weed populations were always lower in mixture treatments than monocultures. There was no complementary effect for mixtures of the two cover crop species. The dry biomass of each cover crop species was proportional to its planting density in the mixtures. After the cover crop season, nematode populations were higher in treatments with sudangrass. However, there was no significant difference in number of nematode infested carrots. The net returns of cover crop treatments were all higher than that of the fallow control because of the reduced cost for hand weeding, and much higher than that of the chemical control because of the cost of chemical treatment.

The results at South Coast were different from the Coachella Valley experiment. Due to the short photoperiod, the growth of sudangrass was reduced compared with the growth of cowpea. In the mixture treatments, the slow growth of sudangrass resulted in cowpea dominance. As a result, the percentage light density under the plant canopy was strongly affected by the percentage of cowpea in the treatments. There was no difference in weed population or weed dry weight between cover crop treatments and the control probably due to low weed populations in the South Coast experiment. Nematode populations were higher in treatments with sudangrass after the harvesting of cover crops. However, there was no significant difference in number of nematode infested carrots among all the treatments. In contrast to the Coachella Valley, the net returns for some cover crop treatments were higher than that of the fallow control. The lower weed populations decreased the weed control benefits of weed control from cover crops. The chemical control treatment, however, still had the highest cost due to the expense of applying metam sodium.